DOCUMENT RESUME

ED 269 452 TM 860 300

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TITLE Florence Nightingale, Statistician: Implications for Teachers of Educational Research.
PUB DATE Apr 86
NOTE 27p.; Paper presented at the Annual Meeting of the American Educational Research Association (70th, San Francisco, CA, April 16-20, 1986).
PUB TYPE Speeches/Conference Papers (150) -- Viewpoints (120) -- Historical Materials (060)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS Adults; *Biographies; Educational Researchers; *Field Studies; Hospitals; Medical Research; *Profiles; Public Health Legislation; Qualitative Research; Questionnaires; *Research Methodology; Role Perception; Social Problems; Social Science Research; *Social Scientists; Statistical Analysis; Statistical Inference; *Statistics
IDENTIFIERS Descriptive Research; *Nightingale (Florence)

ABSTRACT

This paper presents an overview of Florence Nightingale's statistical background and accomplishments; discusses Victorian statistics, Nightingale's education and statistical contributions; and concludes with implications for professors and students of educational research. Florence Nightingale (1820-1910), the first woman elected as a fellow of the Royal Statistical Society, was a well-trained statistician. In common with many of her contemporaries in the social sciences, Nightingale believed that there were laws governing (or describing) human behavior and that statistical data analysis would reveal these laws. Her accomplishments in the field of statistics included calculating mortality statistics in the Crimean War, inventing "coxcombs" or polar area charts, developing statistical records for hospitals, writing an impact study in relation to the possible removal of St. Thomas' Hospital, collecting census data from hospital statistics, developing a questionnaire for the Colonial Office to collect data from the colonies, and collecting data about the effects of incarceration upon future criminal behavior. Nightingale also worked in the areas of qualitative research and descriptive statistics, and she used her research and data behind the scenes to effect legislative changes. Since the majority of students in introductory educational research and statistics courses are women, the inclusion of Florence Nightingale in the history of statistics would provide a female role model. References and a bibliography are appended. (PN)

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Florence Nightingale, Statistician:

Implications for Teachers of Educational Research

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Paper Presented at the:

Annual Meeting of AERA

San Francisco, CA

April, 1986

TM 860 300

Last spring (1985) the Times Higher Education Supplement published a letter-to-the-editor from a Rita Pankhurst on the subject of women "whose achievement in science and engineering has not entered public consciousness." Because the name Pankhurst is well known in English social history, being closely identified with the suffragist movement, we read the letter which otherwise we might have overlooked. To our astonishment we learned that the first woman elected as a fellow of the Royal Statistical Society was none other than Florence Nightingale (1820-1910). Subsequently, we discovered that Nightingale's interest in statistics was so intense that one biographer, E. T. Cook, described her as a "passionate statistician". Except for Helen Walker, who appears to have known about everything statistical (including degrees of freedom as well as Florence Nightingale), educational researchers seem unaware that the "Lady with the Lamp" was also the "First Lady of Statistics". Our paper will deal with this generally unrecognized aspect of Florence Nightingale's life and work. We shall begin with a brief overview of Nightingale's statistical background and accomplishments, followed by a discussion of Victorian statistics, Nightingale's "formal education" and statistical

contributions, and conclude with implications for professors and students of educational research.

Overview

By the standards of her time Florence Nightingale was a well-trained statistician. She had been taught mathematics by her father. She read the works of Adolphe Quetelet, the Belgian who became a founder of the Royal Statistical Society. Nightingale was close to the leading English statisticians of her time. For example she worked with Dr. William Farr on the preparation of medical statistics. She corresponded with Francis Galton. Her application for membership in the Royal Statistical Society was supported by William Guy, William Farr, and William Newmarch.

In common with many of her contemporaries in the social sciences, Nightingale believed that there were laws governing (or describing) human behavior and that statistical data analysis would reveal these laws. She gathered much of her information on India, which she never visited, from questionnaires of her own design. She posed questions (still unanswered) about the effects of incarceration upon future criminal behavior and she expected that data could provide answers. Nightingale was one of the first users of graphical devices including "shaded or colored squares, circles and wedges." Her statistical work was

recognized in this country by her being awarded an honorary membership in the American Statistical Association.

Victorian Statistics

In their second edition of Statistical Methods in Education and Psychology, Glass and Hopkins (1984) offer an anthropomorphic history of statistics.

> "Statistics had a mother who was dedicated to keeping orderly records of governmental units (state and statistics come from the same Latin root, status) and a gambling father who relied on mathematics to increase his skill at playing the odds in games of chance." (p. 2)

Since the late seventeenth century statistics had been taught in Germany to those preparing for civil service. [By another derivation statistics is from staat, the German word for state]. The subject matter was "the comparative description of states and countries, which might take as its purview a wide range of facts concerning population, geography, climate, natural resources, trade, manufacturing, military strength, education, religious observance and, constitutional provisions" (Eyler, 1979, p. 18). These "comparative descriptions" were not necessarily numerical nor was mathematics a requirement in their analysis. If, however, this continental tradition is the mother referred to by Glass and Hopkins, we also need to meet some of the maternal aunts and uncles.

Several uncles spoke French. August Comte, a founder of sociology and the coiner of the term, strongly influenced J. S. Mill. Following Laplace, Comte divided sociology into social statics and social dynamics. As you may recall from high school physics, statics and dynamics are the two major divisions of mechanics. Social physics became the English term for sociology in the social reform meaning and for social statistics. Florence Nightingale corresponded with Benjamin Jowett and Francis Galton about establishing a chair of social physics (social statistics) at Oxford. Loosely, to the Victorians sociology = social physics = social statistics. For example, Eyler (1979, p. ix) describes Victorian social activists as hoping that "statistics would become the positive science of the state. Through the quantitative analysis of current circumstances and problems the means of effecting progressive, orderly social change would be found." Please note the word, positive, in the quotation. It refers to the Comtean positivism. The French word, positif, means based on facts.

Another French-speaking uncle was the Belgian Adolphe Quetelet (1796-1874). Quetelet attended lectures by Laplace from whom he learned that probability and statistics could be used in the analysis of society. Later, he "embarked on an ambitious program to study society as 'social physics,' that is, in terms of empirical relationships obtained through statistics derived

from the methods of celestial mechanics" (Mulaik, 1984, pp. 415-416). Quetelet was a frequent visitor to England, a catalyst for the founding of a statistical section of the British Association for the Advancement of Science, and an influence on Galton as well as Nightingale. Florence Nightingale had some direct association with Quetelet. She corresponded with him, read his books (probably in French), and may have studied, although briefly, with him.

Along with the continental relatives, Victorian statistics had others who were Scots and English. From philosophy there was a tradition of British empiricism carried on by J. S. Mill (1806-1873). It was British empiricism that underlay the Victorian social statistician's attitude towards data and regularities of human behavior. The Baconian role of the statistician was to organize and arrange facts so that the latent descriptive laws might become manifest.

Let us conclude our genealogical history of social statistics by noting the emergence of statistical societies in the 1830's. Most of these societies were located in the large trade and manufacturing cities such as London and Manchester. The members tended to be civic-minded business or professional men--not mathematicians or social scientists. Politically, the participants in these societies were "not rebels but were members of the reforming establishment" (Eyler, 1979, p. 14). By the

1840's, the regional societies had withered but the London society was revived. The new members now tended to be civil servants and actuaries. For the statistical societies "statistics was not merely a method but a separate science" (Eyler, 1979, p. 15). [Is this an adumbration of Scriven's idea of evaluation being more than a social science, indeed being the queen of the social sciences?] And the role of the statistician (or "statist")" was to be the scientific expert on matters of policy, the one who spoke from a knowledge of facts, not from mere conviction. Statistics so understood was a master science encompassing the results of other sciences and directing them to human need" (Eyler, 1979, p. 16). Statistics was managerial; its underpining was libertarian. Sounds like Earnest House's analysis of some modern day evaluation models.

Nightingale and Her Contributions

Florence Nightingale was born at a time and in social circumstances which caused Sir Edward Cook to remark, "Because she was a woman, her early life was one long struggle for liberation from circumstances and social prepossessions" (1913, p. 5). Born in 1820 into a wealthy family, Florence was expected to learn the accomplishments deemed appropriate to young ladies--music, the use of globes, writing books of elegant extracts, working footstools and doing fancy work. In addition, young ladies of "breeding" were expected to be able to run a

large household, plan dinner parties, balls, etc., and make the "required visits".

This would have been the life destined for Florence Nightingale had her father not held views much in advance of the average opinion of his time about the intellectual education of women. William Nightingale, was a well informed man, educated at Edinburgh and Trinity College, Cambridge. He personally supervised his daughters' education, an education which included a range of subjects from grammar, composition, constitutional history, modern languages (French, Italian and German) to Latin, Greek, mathematics, and Roman, German, and Italian history (Cook, 1913; Woodham-Smith, 1951). Extensive travel on the continent and contact with various intellectuals of the day, M. de Candolle, the botanist, Sismondi, the historian, Elic de Beaumont, the geologist, Mignet, de Tocqueville and Thiers, broadened the extensive education Nightingale received at home (Cook, 1915).

While it is clear that Nightingale received an "extensive" education at home and through her travels, it is unclear how or where Nightingale acquired her knowledge and understanding of statistics. Grier and Grier (1978) speculate that she may have gained some background from James Joseph Sylvester, a noted mathematician who published in the area of probability theory and statistics and under whom Nightingale studied. Kopf, writing in

1916, believed that Nightingale was greatly influenced and indeed taught by Aldophe Quetelet, a Belgian mathematician, astronomer, anthropometrist, official social statistician and university teacher. Nightingale was particularly interested in his conception of statistical method as applied to the life of man and from this learned much of the science and art which describes human society in terms of numbers. Kopf also believed that it was from Quetelet, that Nightingale "learned the methods, general aims, and results of qualified inquiry into social facts and forces" (Kopf, 1913, p. 389). Walker concurs that Florence Nightingale was an ardent admirer of Quetelet and noted the inclusion of Quetelet's ideas in Nightingale's correspondence (Walker, 1925). Indeed, of the many letters written by Nightingale, one was to Sir Frances Galton which had several references to Quetelet, including a comment which stated that he gave her his Physique Sociale and his Anthropometric (Walker, 1925).

How Nightingale gained her knowledge of statistics is uncertain, but she did make contributions to the field of statistics and research. In examining and analyzing Nightingale's contributions, it is helpful to think in terms of the various "causes" to which she applied her talents and time. Among these were her work with the British army in the Crimean War, her dealings with both civilian and military hospitals in

Britain, her concerns about India, and her concerns with the social problems of the day.

The first major contribution of Nightingale is her work with the British Army in the Crimean War. Nightingale went to the Crimea in 1854 to answer the question of whether women could be used to nurse the sick and wounded in time of war. From October 1854 to June 1856, she gathered voluminous amounts of data on everything from the laundry, food, conditions of the hospitals, and mortality rate among the wounded. Among other things, she found that the methods used to record the deaths of soldiers were woefully lacking or discordant. If a soldier died while on one of the transport ships for the sick or wounded, he was not included in the number of soldiers killed or if he died while in the hospital he may not have been counted. Also, the method of calculating mortality among those counted rendered mortality rates that greatly underestimated actuality. Nightingale recommended uniform record keeping measures and developed a formula which gave a truer picture of mortality among the sick and wounded. Her formula consisted of considering the number of admissions and discharges in a certain period from which she derived the number of cases treated. She then set up a ratio of "numbers treated" over "number of deaths" to come up with the mortality rate. Nightingale also computed the average number of days each case remained in the hospital. She kept mortality

statistics over the period of a year. Nightingale represented her findings in a series of illustrations in which she superimposed circles of different colors--red, depicting death from wounds, blue, the preventable, and black other (Nightingale, 1858a). According to Grier and Grier, these illustrations, known as "coxcombs" or polar area charts, were invented by Nightingale, and required mathematical knowledge of computing areas in polar coordinate systems as well as the reverse of using the area to determine the needed radius (Grier, & Grier, 1978).

In addition to the "quantitative" methods Nightingale utilized, one could say that she also used qualitative methodologies. She described the life of the soldier in detail including his food, his clothing, etc. In her Notes on Matters Affecting the Health, Efficiency, and Hospital Administration of the British Army, Nightingale noted that each man was issued a kit by the Army which included such things as shirts, a belt, towels, knife, fork, spoon and comb. The soldiers, according to Nightingale, were expected to bring their kits with them to the hospital from the battlefield. If they did not bring these articles, they went without them (Nightingale, 1858a). Nightingale also dealt in great detail with the amount of laundry done in relation to the number of sick in the hospital. She described the method of transport of the sick, "Sick were received on board and sometimes detained several days before the

vessels sailed... The voyage for sailing vessels was six days and for steamships under two days but the average time was eight days" (Nightingale, 1858b, p. 363). She discussed the physical layout of the hospitals and the amount of space each soldier had in the hospital. These descriptions were not always totally objective but at least an attempt was made to describe the context from which the statistics were extracted. Nightingale felt the need for observation and description, when she stated, "Statistics tell nothing without conditions" (Nightingale, 1858a, p. 141).

On her return from the Crimea, Nightingale continued her research of the military and civilian hospital medical care. She computed the mortality rate of nurses in the Crimea. Upon her return to England, Nightingale did a comparison of the mortality rate of nurses in 15 London hospitals with non-nurse female mortality rates for the period 1848-1857. All subjects both nurse and non-nurse had died from fever and cholera. Nightingale found that the annual mortality rate for nurses depending on age ranged from 9.53/1000 to 14.26/1000 population while the non-nurse population had an annual mortality rate of 2.19/1000 to 4.94/1000 (Nightingale, 1859a).

Nightingale (1858a) also used comparison groups of soldiers and non-soldiers of the same age to calculate expected versus actual deaths. She summarized her findings in a table which

included information from 1839 to 1853. Nightingale was one of the first persons to use comparison studies to show expected versus observed frequencies. The use of tables to present and summarize data had limited use prior to Nightingale. By her own report, Dr. William Farr, helped her to create some of the tables which she used extensively in her research (Nightingale, 1859a).

Turning her attention to civilian hospitals, Nightingale found a deplorable lack of uniformity in the recording of hospital statistics. Each hospital followed its own nomenclature and classification so that it was impossible to compare the statistics of one hospital with another. With the assistance of Dr. Farr, Nightingale drew up a standard list of diseases and a set of model statistical forms. The statistical forms contained legends for classifying the diseases of the patients and areas to register admission dates, discharges, sex, age, duration of stay in days, and deaths. With these forms, Nightingale hoped "to obtain a uniform record of facts from which to deduce statistical results among which are the total sick population...the number of cases of each age, sex, and disease...the average duration in days...the mortality from each disease" (Nightingale, 1859a, p. 162).

With these forms, Nightingale felt that data obtained could be used to influence laws which regulated actions taken toward diseases, influence hospital economics, predict those at risk for

certain diseases, and render proportionate mortality rates (Nightingale, 1859a). She had the forms printed using her own money and persuaded some of the London Hospitals to adopt them experimentally. Information obtained using these forms was introduced at the International Statistical Congress, held in London in 1860. Following this Congress, several hospitals both in England and elsewhere adopted the forms. The statistics of the various hospitals adopting her forms were published in the Journal of the Royal Statistical Society in September 1862 (Kopf, 1913). Although the forms were dropped because of expense involved, as Palmer stated "the Nightingale influence of a century ago can be seen in the standard nomenclature and system used internationally today" (Palmer, 1977, p. 88).

Another study related to civilian hospitals which Nightingale undertook had to do with the questions related to the possible removal of St. Thomas' Hospital at the insistance of the Southeastern Railway who wanted to extend their railway route. In completing this study, Nightingale, according to Kopf, "analyzed the origins of cases served by the hospital, tabulated the proportions of cases within certain radial distances of the hospital and showed the probable effect upon patients of the removal of the hospital to the several possible sites suggested" (Kopf, 1916, p. 396). This "impact study" provided legislators with data to make more informed decisions.

From hospital statistics, Nightingale turned her attention to the collection of census data. She made a determined effort to include in the data collected, information on the sick and infirm and housing. Nightingale felt there was a connection between health and the dwellings of the population. The data collected would serve as a foundation for sanitary reform (Kopf, 1916). In this regard, Nightingale was far ahead of her day for although the legislature denied the request later censuses in Britain and other countries included data on illness and housing.

After studying the civilian and military medical systems, Nightingale turned to the study of aboriginal races in the colonies and to the sanitary and material welfare of the population and military establishment of India. With the assistance of the Duke of Newcastle, Nightingale developed a questionnaire which was sent by the Colonial Office to the governors of the various colonies. From the returns of the 143 schools, she calculated the mortality rate of school children by age and sex, and further classified the statistics by causes of death. A second questionnaire gathered information on colonial hospitals and the high mortality among the native races. The second questionnaire yielded a small number of cases so that errors could be high, but the conclusions Nightingale drew about native sanitary conditions and mortality rates were sound (Kopf, 1916).

In looking at the sanitary conditions of the natives and military establishment in India, Nightingale again developed a questionnaire which she sent to the 200 medical stations in India. Speaking of this questionnaire, Kopf stated, "The inquiry form lacked little in requisite completeness and precision of detail" (Kopf, 1916, p. 401). The use of questionnaires to gather data was rare in the 1850's. Through the use of this questionnaire, Nightingale was able to collect, tabulate, and interpret data. She concluded that mortality was due primarily to overcrowding, contaminated food and water, and bad drainage. Most of the data, Nightingale gathered, was included in the report of the Indian Sanitary Commission of 1863 (Boyd, 1982). Appropriate reform measures were suggested and Nightingale used her considerable influence to get these enacted and carried out.

From sanitary conditions, Nightingale turned to agricultural problems in India for which she collected data on irrigation and its affect on life and death of the people. She also was concerned about and collected data on education in India. The question, Nightingale felt, was "how to create a public health department for India—how to bring a higher civilization into India" (Nightingale, 1863, p. 509).

Nightingale, in addition to the British Army, civilian hospitals, and India, was interested in poverty, crime, and education in England. She urged research into the underlying

causes of poverty and crime. In a letter to Galton she noted that little was known about the results of Forster's Act requiring universal education. She posed such questions as: "What proportion of children forget their whole education after leaving school; whether all they have been taught is waste?" "If we know not what are the effects upon our national life of Forster's Act is not this a strange gap in reasonable England's knowledge? What effect has education on crime? Is the career of a criminal from his first commital to his last, whether (a) to the gallows, or (b) to rehabilitation, recorded? What is the proportion of children de-pauperised or pauperised by the Workhouse?" (Walker, 1929, p. 173). In other forms, these questions are still being asked.

So strongly did she feel about statistics and the study of social law that she tried to establish a chair in applied statistics at Oxford. To accomplish this end she applied to both Benjamin Jowelt and Sir Francis Galton. The project was abandoned after the death of Jowelt and did not come to fruition until after her death (Grier & Grier, 1978).

Though Florence Nightingale was deeply involved for most of her adult life in research and statistics, her work is not widely known. One could conclude that her research and work in statistics had minimal impact. This conclusion would be at variance with that of Pearson who in speaking of Nightingale's

letter to Galton called her "the prophetess...proclaiming my own creed...What is more is more it is almost as true today as it was thirty years" (In Walker, 1929, p. 174). (Coincidentially, the questions Nightingale asked in 1891 concerning crime and education are still being asked today over 60 years after the time of Pearson.) So why then this lack of recognition? Several explanations can be proposed. First, few of her works were published except privately and of those only a limited number. Second, Nightingale lived and worked in Victorian England where the role of women was limited (to say the least). Nighingale used her research and data "behind the scenes" to effect legislative changes. She preferred to work through various men who could "display" their power. Finally, for approximately the last fifty years of her life, Nightingale was an invalid rarely seen in public. Without public exposure, much of her work would remain known only to those with whom she came in direct contact or with whom she corresponded.

Education Implications

In our current preoccupation with inferential statistics, we tend to forget the part descriptive social statistics has played--and is playing--in social reform and in social control (perhaps two sides of the same coin). During the nineteenth century, as now, there was the belief that facts could speak for themselves and that facts could persuade. As Mr. Gradgrind in

Dickens' Hard Times put it: "Facts alone are wanted in life....You can only form the minds of reasoning animals upon Facts; nothing else will ever be of any service to them." Florence Nightingale's version was: "Facts are everything--doctrines are nothing." Concomitant with a reliance on facts or data was a belief that human progress is inevitable, a belief shored up by a Darwinianlike evolution of social life. Facts and statistics could be the instruments of reform and the betterment of humankind. Seen from this perspective, the work of Florence Nightingale is to be placed alongside that of Charles Booth (Life and Labour of the People of London) and Friedrich Engels (Conditions of the Working Class in England).

Descriptive statistics is viewed in many instances as a "step-child" in the field of statistics. Yet descriptive statistics are necessary as a basis for dealing with data, for describing the subjects, groups, eto. from which inferences are made to a larger population. Both types of statistics are important to the research process. It would be helpful for our students to realize how powerful the use of descriptive statistics was and can be. The masterful use of descriptive statistics by Florence Nightingale may serve as an example to our students so that they may have a better appreciation of this type of statistics.

While the controversy over qualitative versus quantitative research methodologies continues to be in the forefront in the literature, our students might take a lesson from Florence Nightingale who used both in her work. While questions may be raised as to the objectivity of and conclusions drawn by Nightingale, her work would provide examples for critique and study. Utilization of both types of methodologies may give us a more complete and truer "picture" of that which we wish to study.

Ethics is another area where the work of Nightingale could be used in teaching research and statistics. One critic, F. B. Smith, 1982, felt that Nightingale's conclusions (especially in the Crimea) were based on selected data. Students must learn to look at all the data, not just at that which supports their conclusions.

Finally, the majority of our students in introductory educational research and statistics courses are women, many of whom exhibit great math anxiety. Unfortunately, these students think of mathematics and statistics as men's fields and that women are not capable in these areas. These attitudes may be reinforced when we relate the history of statistics because the principal figures cited are often male. The inclusion of Florence Nightingale would provide a female role model. Some of the "Founding Fathers" (Pearson and Galton) apparently felt that she had made a significant contribution so that it might be appropriate for us to include her also.

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